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High-field magnetotransport in microstructures of the frustrated antiferromagnet Yb_2Pt_2Pb

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Introduction

Frustrated quantum magnets exhibit a rich variety of non-trivial quantum ground states due to their remnant entropy at zero temperature. Most studied materials are insulators, with magnetic coupling of localized spins mediated by exchange interactions. Yb_2Pt_2Pb (YPP) is a rare example of a metallic frustrated quantum magnet, where Yb^{3+} J=7/2 moments are arranged in dimers forming a Shastry-Sutherland lattice [1,2]. In addition, the itinerant charge carriers of the metal provide gapless excitations able to mediate magnetic interactions (RKKY) as well as hybridize with the 4f-states, which has been proposed to lead to a novel charge-orbital separation [3]. YPP orders antiferromagnetically (AFM) below T_N = 2.1 K, and strong g-factor anisotropy confines the spins into the *ab* planes. Accordingly, fields aligned parallel to the planes suppress the AFM order already below 4 T, while fields of up to 65 T along the *c* direction do not lead to saturation in the magnetization and step-like features even at B ~ 25 T were observed [4]. Here we probe the electronic structure of YPP by quantum oscillation and conductivity measurements in high fields, which tune the energy balance of the 4f states and thus the degree of charge-orbital separation.

Experimental

The main focus of this experiment was to investigate the anisotropic magnetic scattering with respect to the dimer layers. YPP is a good metal (ρ_0 ~ 10 μΩcm), rendering measurements of conductivity anisotropy on single crystals challenging. Therefore, we micro-machined electric-transport devices from YPP crystals by focused ion beam (FIB) machining, defining regular resistance bar geometries for resistivity measurements for currents applied within and perpendicular to the magnetic layers.

Results and Discussion

Figure 1 shows the field dependence of the resistance, $R(B)$, of YPP in pulsed fields up to 65T. Two current directions were probed simultaneously for various field orientations at T = 0.7 K. Black curves correspond to fields aligned parallel to the planes along [100]. Below ~ 5 T a broad hump with two peaks appears that originates from strong spin-dependent scattering. As the field orientation is changed to perpendicular this spin-dependent region broadens, ranging until about 35 T (red dotted lines in Fig. 1 mark the turning points). Above, $R(B)$ exhibits a monotonic increase in field. This turning point likely indicates loss of AFM order for the *c* direction. On top of the magnetoresistance for I || [100] and B || [100], magnetic quantum oscillations (MQOs) appear that correspond to at least two different frequencies while none are discernible in the interlayer transport. In addition, we find no signs of saturation of $R(B)|_{B \parallel [001]}$, as expected for normal 3D metals, instead it follows a linear field dependence at any angular orientation up to 65 T. We intend to continue this project by mapping the Fermi surface via the angle and temperature dependence of MQOs to understand how the crystal fields modified by strong Zeeman energy in high fields influence the electronic structure of YPP.

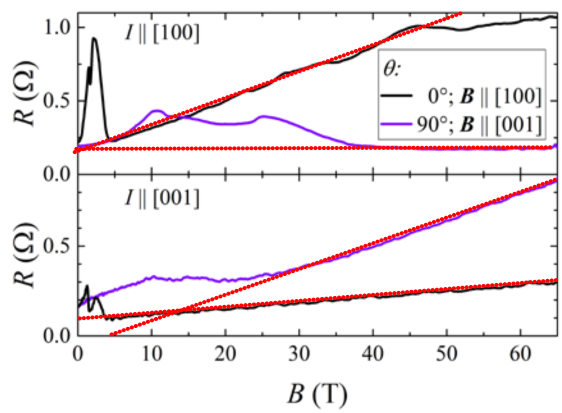

Fig.1 Field dependence of the Resistance for currents and magnetic field applied along the [100] and [001] direction; T = 0.7 K. Red dotted lines are guides to the eye.

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